DOCUMENT RESUME

ED 389 279 IR 017 490

AUTHOR	Wallace, Andrew R.; Sinclair, Kenneth E.
TITLE	Affective Responses and Cognitive Models of the Computing Environment.
PUB DATE	Apr 95
NOTE	17p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, CA, April 18-22, 1995).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Case Studies; *Cognitive Structures; *Computer Anxiety; *Computer Attitudes; Computer Literacy; Computer Science Education; *Computer Uses in Education; Foreign Countries; Higher Education; Interviews; *Preservice Teacher Education; Sex Differences; Users (Information)
IDENTIFIERS	Australia

ABSTRACT

New electronic technologies provide powerful tools for managing and processing the rapidly increasing amounts of information available for learning; teachers, however, have often been slow in integrating computers into the curriculum. This study addresses the question of how prospective teachers construct affective and cognitive models about computer environments. The study involved 177 first year students taking two different courses at a rural university in Australia; the first group was composed of 92 pre-service elementary school teacher trainees who were involved in a technology subject containing a computing component and the second group was made up of students majoring in computer studies. Students in both groups were administered a mixture of instruments that included affective (anxiety and attitude) and cognitive (knowledge and mental models) measures through questionnaires and interviews. Teacher education students as a group were found to be less knowledgeable, more anxious, less confident, and to have less liking for interactions with computers than the other group. Among teacher education students, female students were found to be more anxious and less confident with computers than male students; there were no anxiety differences between male and female students in the computer science course. Carefully planned courses and application experience addressing both affective responses and cognitive understandings are needed in order for teacher education students to be able to use technology effectively in classroom teaching and learning. (Contains 30 references.) (AEF)

Affective responses and cognitive models of the computing environment

Andrew R. Wallace
Senior Lecturer in Education, Charles Sturt University

Kenneth E. Sinclair
Associate Professor, Sydney University

American Educational Research Association
April, 1995. San Francisco.

Affective responses and cognitive models of the computing environment

* **Andrew R. WALLACE**, Charles Sturt University.
* **Kenneth E. SINCLAIR**, Sydney University.

Andrew R. Wallace, Senior Lecturer in Ed., Charles Sturt University, P.O. Box 588, Wagga Wagga. NSW. 2650. Australia.
email: wallace@zac.riv.csu.edu.au

Teachers and students are key users of information and the new electronic information technologies provide powerful tools for managing and processing the rapidly increasing amounts of information available for learning. In response to this development there has been a sharp increase in the numbers of computers in schools. Teachers, however, have often been slow in integrating the use of computers into the teaching of subjects within the school curriculum. Sometimes this has been because of a reluctance to change teaching methods and the resources which have been successfully used over many years. Sometimes it is because of anxieties about their ability to master the use of the computers (Hunt and Bohlin, 1991).

The present study addresses the question of how prospective teachers construct affective and cognitive models about computer environments. Despite disagreement about the precise definition of the concept of mental model, intuitively it refers to the "creation and internalisation of simplified models of reality" (Payne, 1992). Anxiety and confidence will feature prominently in affective models developed for understanding and explaining affective reactions to computer environments. McInerney, McInerney and Sinclair (1994, p4) define computer anxiety as "an affective response of apprehension or fear of computer technology accompanied by feelings of nervousness, intimidation or hostility". These feelings of anxiety may be accompanied by negative cognitions and attitudes towards technology, including fears about looking foolish and damaging the computer.

Several correlates of computer anxiety have previously been examined, including gender and computer experience (Joncour, Sinclair and Bailey, 1994). Research examining gender has produced inconsistent results, with several researchers reporting no gender differences in computer anxiety (Glass and Knight 1988, Pope-Davis and Vispoel, 1993) and others (McInerney et al 1994, Okebukola, 1993) finding that females report higher computer anxiety than males. Similarly, investigations of the effects of computer experience on computer anxiety have produced varied results. Loyd and Gressard (1984) and McInerney et al (1994) have found that computer experience is associated with low computer anxiety. In contrast, King (1993) and Rosen, Sears and Weil (1987) found that a period of computer interaction increased rather than decreased computer anxiety.

Models for understanding and explaining affective reactions to computer environments are accompanied by cognitive models for understanding and explaining how computers function in the processing of information. In human computer interaction, those cognitive models, or representations have been shown to have important consequences for further learning about computers and the design of instructional materials (Sasse, 1992). A review of some investigations into user's models of computer systems has been presented by Sasse (1992). Such models are constructed within the mind by the learner, based upon perceptions of reality (Boylan, Hill, Wallace and Wheeler 1992).

It might also be expected that the affective and cognitive models associated with using computers would be closely related. Accurate and effective cognitive models would be expected to accompany feelings of confidence about ability using computers while inaccurate and disfunctional cognitive models might be expected to accompany feelings of anxiety.

The computer environment within which the computer user operates has been conceptualised by Wallace, Hemmings, and Hill (1991), and is summarised in Figure 1.

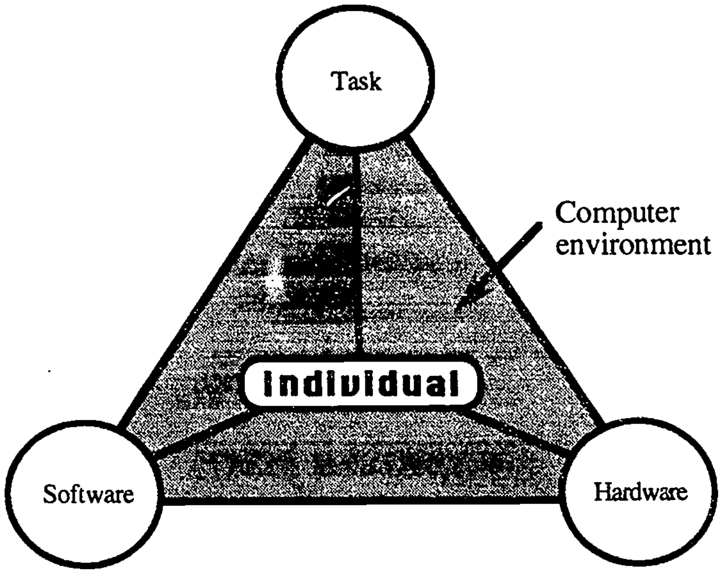

Figure 1. The computing environment

The representation is essentially a constructivist one, with the student at the centre. It describes an environment in which the individual makes sense of his/her interactions with the hardware and software in the context of a range of computing tasks. Lines indicate interrelationships which are interpreted by the student. These same lines also provide a boundary to the system which we have called the computer environment. It is a centre to periphery model which reflects the individual's immediate concerns with task, software, and hardware and with later concerns with the interactions between them. This computing environment impacts upon both the cognitive and affective domains.

Method

The study involved 177 first year students taking two different courses at a rural university in Australia. The first group was composed of 92 pre-service elementary school teacher trainees (22 male and 70 female), who were involved in a technology subject which contained a computing component. This component was made up of four hours of computer laboratory time per week, and involved application software (wordprocessing, databases, spreadsheets, graphics, communication). Assessment was by way of assignments demonstrating mastery. There was no examination. The course aimed at developing skills in computing which might then form the basis for the effective use of computers in classrooms.

The second group was made up of students majoring in computer studies, doing degrees in computer science or business (54 males, and 31 females). This group studied a minimum of two full subjects in computing during the semester. The students were assessed by examinations and content based assignments. Their studies included computer programming, and a variety of computing modules (e.g. operating systems, data storage and manipulation, algorithms, languages, software engineering, data structures, file structures, database structures, artificial intelligence). The subjects studied were part of a major in computing, which was the goal of this group of students. They were preparing for careers in computer related fields.

The expectations and outcomes for the two courses were therefore very different, as was the long-term vocational thrusts of the courses of study. This had implications for the amount of time spent at the computer during the semester, and the nature of the evaluation to be anticipated during the course.

Students in both groups were administered a mixture of instruments at intervals across a semester of study. They included affective and cognitive measures, through questionnaires and interviews.

Affective Measures

The affective measures focussed on anxiety, attitude and self concept.

Anxiety

Anxiety was assessed using the State-Trait Anxiety Inventory (STAI) of Spielberger, Gorsuch, and Lushene (1970). This widely used instrument measures State anxiety and Trait anxiety (A-State, A-Trait) in the normal population.

The A-Trait was administered to all students before the semester began. The A-State scale was adapted for use within the computer context, to establish the nature of the anxiety aroused among subjects when working within the computing environment. The essential qualities thus evaluated by the A-State scale involve feelings of tension, nervousness, worry, and apprehension when working within the computer environment. The A-State was administered at the beginning and also at the end of the semester.

Attitude

Loyd and Gressard's (1984) Computer Attitude Scale (CAS) was used to examine attitudes to the computer. The instrument provides a total score and scores on three subscales - Computer Anxiety, Computer Confidence and Computer Liking. Each subscale consists of 10 items and presents positively and negatively worded statements such as "Once I start to work with a computer, I would find it hard to stop" or "I do not enjoy talking with others about computers". This instrument employs a four point scale in which the participants indicate their feelings by selecting one of four choices. It does not include a neutral choice of "I don't know".

Given that the STAI was used to measure anxiety, both State and Trait, the analysis of results from the CAS concentrated on the *Computer Confidence* and *Computer Liking* subscales of the Computer Attitude Scale.

Self Concept

A series of items assessing student self concept in computing, mathematics, problem solving and languages was administered. They each involved items using five point scales.

Cognitive Measures

Declarative knowledge underpins the cognitive models we hold about computer environments, and is readily acquired, static and is available for reflection (Gagné, Yekovich and Yekovich 1993). Procedural knowledge, on the other hand is dynamic, and results in some outcome, and it relies in part upon a declarative base. Ultimately mental models are the basis upon which decisions are made, as they involve the interaction between declarative and procedural knowledge. This results in linkages between schemata and production systems (Gagné, Yekovich and Yekovich 1993). Our analysis follows the path from declarative knowledge to cognitive models of the computer environment. Mental models underscore and direct action within the computer environment, and thus need to be part of an analysis of interacting cognitive and affective processing, directing actions and providing overlaps with affective processes.

The instruments selected dealt with differences in these knowledge levels. Cognitive measures centred on a pencil and paper instrument to establish the level of declarative knowledge about the computer environment, while an integration of interviews with questionnaire data was required to examine the mental models evident in the groups.

Knowledge

A test of student declarative knowledge about the computer environment which was independent of course structure was essential to the research design. The instrument needed to provide details of student understandings of how the computer works and of the interaction between software, hardware and task within the computer environment. Surprisingly, very few tests have been reported in the literature which establish base levels of computer knowledge.

An instrument to measure *computer literacy* developed by the Education Testing Service (ETS) in the United States was adopted. Our focus was narrower than that of the original instrument (Massoud 1991), and the target audience was quite different. A revised instrument was independently assessed by experts to ensure the validity of the total instrument.

Following initial data collection the items in the instrument were subjected to item response analysis, after which items were dropped which did not discriminate across the university population. The revised instrument consisted of only 21 items, with a Cronbach Alpha = .76. The revised instrument was used for data collection at the end of the semester, and only items contained within it were used for subsequent analysis.

Mental Models

A major part of the study involved a semi-structured interview administered while students were working within the computer environment. This method, previously reported by Wallace, Hill, and Hemmings (1991) as Computer-Promoted Dialogue (CPD), was derived in part from *interview-about-instances* (Osborne and Gilbert, 1979) technique, and has been refined in a number of school and university settings. The method utilised a combination of a taped structured interview and short questionnaires, centred on a tailored computer program. CPD is used to access procedural knowledge and to draw students into meaningful discourse as they interacted at each step of the computer program. The software included segments written to probe student understandings of components of the computer system, and the interaction between these parts (e.g. disk drive, CPU, monitor). It also monitored student performance by recording responses to keyboard exercises as well as presenting a number of computer based activities (Wallace, Hemmings and Hill, 1994).

Students were selected for these interviews on the basis of responses to the initial questionnaire. Part of that instrument included items based upon the work of Benner (1984). Benner asked subjects to nominate "critical incidents" in their work situations which caused them to reflect upon events which have influenced their patterns of thought This open ended approach appears to tap into current mental situations, with students asked to nominate critical incidents concerned with recent success or failure. This method was adopted. Students were also asked to describe a number of basic computer operations in open ended questions.

Ultimately the CPD was used to isolate the mental models held by the students, and to explore the level of understanding of the computer environment within which they were working. Models which emerged from these interviews were offered as alternative explanations of computer functioning in a battery of four questions administered at the end of the semester.

Results

The results are presented initially for affective, then for cognitive variables. This section concludes with a discussion of the interrelationships between affective and cognitive constructions.

Affective variables

Anxiety

The table below presents a summary of the descriptive statistics for both trait anxiety, and computer-anxiety (state anxiety) at the beginning and end of the semester.

Table 1: Anxiety levels across the semester

	Trait Anxiety		Initial Comp.Anxiety		Final Comp. Anxiety	
	Mean	SD	Mean	SD	Mean	SD
Total All	48.48	2.85	40.24	1.67	39.39	10.96
Male	48.64	3.00	35.52	9.48	36.62	10.17
Female	48.49	2.84	42.77	12.57	40.97	11.26
Computer Studies All	48.46	2.71	36.31	8.59	36.75	10.68
Male	48.53	2.85	35.73	9.11	36.98	10.71
Female	48.30	2.48	37.43	7.54	36.30	10.85
Education All	48.51	2.97	43.38	12.84	41.51	10.79
Male	47.71	2.97	35.59	10.64	36.59	8.36
Female	48.71	2.96	45.32	12.67	42.74	11.02

A factorial ANOVA was used, and no significant differences in trait anxiety occurred across the groups (F=0.204, p=0.65), nor by gender (F=0.24, p=0.63). Neither group is more likely than the other to be prone to general anxiety.

Significant differences in state anxiety within the computer environment did however occur across the two groups (F=8.16, p=0.005), and by gender (F=5.25, p=0.023) at the beginning of the semester. Education students were found to be more anxious than computer studies student, and females were more anxious than males in each group. There was also a significant interaction between gender and group (F=5.37, p=0.022).While there were no differences in computer anxiety between males and females in the computer science course, females were significantly more anxious than males in the education course. Multiple Range tests (Newman-Kuels) suggested significant differences existed between the females studying education and all the other students. These females were more anxious than the females in computer studies, as well as being more anxious than males in either group.

A repeated measures design was adopted to measure change across the semester which could be related to the respective courses being undertaken in the two groups. In summary, the significant differences in computer anxiety between the two groups of students and the two genders observed at the beginning of the semester remained at the end of the semester. Significant changes in computer anxiety did not occur over the period of the semester courses. In short, despite differences between the two courses, no significant differences were found between the changing anxiety levels for either group or gender. These results are given in the table below.

Table 2: Repeated Measures ANOVA of Computer (State) Anxiety.

Source of Variation	SS	DF	MS	F	Prob
Between-Subjects Effects (Pre-Post test average).					
Group	958.71	1	958.71	4.97	.027
Sex	917.15	1	917.15	4.75	.031
Group by Sex	947.78	1	947.78	4.91	.028
Subjects Within Groups	29332.73	152	192.98		
Within-Subject Effect (Pre-Post test difference).					
Occasion	.07	1	.07	.00	.968
Group by Occasion	34.13	1	34.13	.81	.370
Sex by Occasion	71.52	1	71.52	1.69	.195
Group by Sex by Occasion	28.52	1	28.52	.68	.413
Occasion by Subjects Within Groups	6420.56	152	42.24		

Attitude

The table below presents a summary of the descriptive statistics for computer liking and computer confidence at the beginning and end of the semester.

Table 3: Attitude Measures - for all students

		Computer Liking				Computer confidence			
		Initial		Final		Initial		Final	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total	**All**	35.39	7.10	32.92	8.53	35.88	6.82	34.92	7.80
	Male	38.05	5.97	36.57	7.35	39.10	5.79	38.46	6.34
	Female	33.55	7.26	30.38	8.40	33.65	6.61	32.46	7.81
Computer Studies	**All**	39.16	5.42	37.76	6.64	39.59	5.71	38.96	6.28
	Male	39.62	5.23	38.13	6.00	40.36	5.63	39.67	6.21
	Female	38.26	5.81	37.04	5.96	38.09	5.69	37.57	6.32
Education	**All**	32.41	6.87	29.08	7.90	32.94	6.19	31.72	7.43
	Male	34.11	6.06	32.67	6.92	35.94	5.07	35.44	5.78
	Female	31.96	7.04	28.13	7.92	32.15	6.25	30.74	7.54

Factor Analysis was used to validate the Computer Liking and Computer Confidence subscales, and were confirmed as being independent of each other.

Significant differences existed across the groups for Computer Liking (F=27.26, p=0.000). Males and females in the Computer Studies group scored higher on computer liking than education students. Within each group however, there were no significant differences between females and males in ratings of Computer Liking (F=2.29, p=0.13). Males and females reported similar levels of Computer Liking within each group.

A repeated measures design was employed to examine change over time. Small but significant negative changes were noted across the semester for Computer Liking, but not with regard to group or gender.

Table 4: Repeated Measures ANOVA of Computer Liking

Source of Variation	SS	DF	MS	F	Prob
Between-Subjects Effects (Pre-Post test average).					
Group	2523.21	1	2523.21	32.74	.000
Sex	307.27	1	307.27	3.99	.048
Group by Sex	66.06	1	66.06	.86	.356
Subjects Within Groups	11560.88	150	77.07		
Within-Subject Effect (Pre-Post test difference).					
Occasion	233.85	1	233.85	15.42	.000
Group by Occasion	24.13	1	24.13	1.59	.209
Sex by Occasion	16.34	1	16.34	1.08	.301
Group by Sex by Occasion	25.84	1	25.84	1.70	.194
Occasion by Subjects Within Groups	2274.74	150	15.16		

A factorial ANOVA was undertaken for Computer Confidence. Significant differences existed across the groups (F=24.42, p=0.000), and significant differences also existed between the genders (F=7.75, p=0.006), but there was no significant interaction. Males and females in the Computer Studies group scored higher on Computer Confidence than education students, while in each group males scored higher than females in Computer Confidence.

Again, a repeated measures design was employed to examine change over time. As with Computer Liking, small negative changes were noted from the beginning to the end of the semester course for Computer Confidence, though these were not significant, as indicated in Table 5 below.

Table 5: Repeated Measures ANOVA of Computer Confidence

Source of Variation	SS	DF	MS	F	Prob
Between-Subjects Effects (Pre-Post test average).					
Group	1684.64	1	1684.64	24.67	.000
Sex	609.75	1	609.75	8.93	.003
Group by Sex	62.92	1	62.92	.92	.339
Subjects Within Groups	10243.77	150	68.29		
Within-Subject Effect (Pre-Post test difference).					
Occasion	35.85	1	35.85	2.89	.091
Group by Occasion	1.81	1	1.81	.15	.703
Sex by Occasion	2.04	1	2.04	.16	.686
Group by Sex by Occasion	4.28	1	4.28	.35	.558
Occasion by Subjects Within Groups	1861.18	150	12.41		

Self Assessment Scales

Finally, students were asked to reflect upon their own perceptions of their abilities. These were presented as five point scales, in a number of separate items. Factor analysis confirmed that four discrete factors existed within the questions, which were then developed as composite scores for perceived abilities in computing, mathematics, general problem solving, and languages. Each composite score was made up of two or three items, results for which are presented in Table 6.

Table 6: Self Assessment

	Computer Skills (/15)		Maths Ability (/10)		Language Learning (/10)		Problem Solving (/10)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total All	8.53	2.11	6.44	1.36	6.24	1.55	6.15	1.40
Male	9.17	2.22	6.63	1.34	6.20	1.47	6.75	1.25
Female	8.06	1.90	6.30	1.37	6.26	1.62	5.72	1.35
Computer Studies								
All	9.46	1.84	6.55	1 38	6.30	1.52	6.51	1.43
Male	9.73	1.90	6.64	1.30	6.12	1.50	6.83	1.27
Female	8.96	.58	6.39	1.45	6.68	1.47	6.04	1.48
Education								
All	7.67	1.98	6.33	1.34	6.17	1.59	5.82	1.31
Male	8.00	2.38	6.63	1.42	6.58	1.47	6.53	1.17
Female	7.53	1.94	6.22	1.29	6.14	1.78	5.56	1.34

The self assessment composite scales were examined using SPSS MANOVA. In this analysis the four composite scores were used as dependent variables against gender and group. There were significant multivariate results for both gender (F=4.39, p=0.002) and group (F=6.07, p=0.000), but not for group by gender interaction. Subsequent univariate tests where then undertaken for the effects of group and gender, with adjusted alpha levels using the Bonferroni Inequality.

The Computing Skills composite showed significant differences between the groups (F=23.01828, p=0.000), but there were no significant differences by gender (F=1.78, p=0.18). Students in the Computer Science group perceived that they had higher levels of computer skills than did the Education students.

No significant differences were found between the groups in terms of self assessment of ability in mathematics (F=.213, p=0.65), nor by gender (F=1.29, p=0.26). The groups were basically the same in terms of individual assessments of ability in mathematics.

The groups were also similar in their assessment ability in language. No significant differences were found between the groups (F=.096, p=0.79), nor between the genders (F=.082, p=0.775).

Finally, the composite scale for problem solving showed no significant differences between the groups (F=2.04, p=0.15), but there were significant differences between males and females (F=13.85, p=0.000). Males in each group rated themselves higher in problem solving ability than did the females.

Cognitive measures

Knowledge

The table below presents a summary of the descriptive statistics for student declarative knowledge about the computer environment at the beginning and end of the semester.

Table 7: Knowledge Measures - for all students

		Prior Knowledge		Final Knowledge	
		Mean	SD	Mean	SD
Total	**All**	14.74	3.79	15.32	3.30
	Male	16.44	3.45	16.59	3.36
	Female	13.57	3.59	14.45	2.98
Computer Studies					
	All	16.90	3.19	17.21	2.59
	Male	17.54	2.90	17.63	2.79
	Female	15.72	3.40	16.44	2.00
Education					
	All	12.95	3.30	13.77	3.01
	Male	13.61	3.15	13.94	3.28
	Female	12.78	3.34	13.72	2.96

A factorial MANOVA was done on prior knowledge scores. Significant differences were noted by gender (F=5.47, p=0.02), and also by group (F=34.12, p=0.000). Computer studies students recorded higher levels of declarative knowledge about computers than did the education students. Multiple Range tests (Newman-Kuels) were also employed, suggesting that significant differences existed between the males studying computer studies and all other students at the 0.05 level, and that females were significantly different across groups at the 0.05 level. There was no significant interaction between group and gender (F=.725, p=0.396).

As indicated below, these differences were maintained across the semester, with knowledge levels rising in parallel for both groups. A repeated measures ANOVA design was employed. Within-subject effects were not significant.

Table 8: Repeated Measures ANOVA of Computer Knowledge

Source of Variation	SS	DF	MS	F	Prob
Between-Subjects Effects (Pre-Post test average).					
Group	667.86	1	667.86	43.16	.000
Sex	62.73	1	62.73	4.05	.046
Group by Sex	14.53	1	14.53	.94	.334
Subjects Within Groups	2367.71	153	15.48		
Within-Subject Effect (Pre-Post test difference).					
Occasion	16.41	1	16.41	5.98	.016
Group by Occasion	.83	1	.83	.30	.584
Sex by Occasion	5.83	1	5.83	2.12	.147
Group by Sex by Occasion	.00	1	.00	.00	.976
Occasion by Subjects Within Groups	420.23	153	2.75		

Mental Models

Preliminary analysis of the interview transcripts suggested models which were then tested with the whole group. These models were developed in part from the content of student responses, and also from the language used to describe aspects of the computer environment during the CPD. The themes which emerged related to data storage on the disk, the role of the disk, computer memory, and the role of the CPU. These models were then offered as alternatives in multiple choice questions dealing with these broad issues.

While further analysis of the transcripts is still in progress, initial investigation of these multiple choice questions suggests that patterns are emerging in the responses. The investigation of one of these questions concerns the evidence contained in the interview transcripts about the relationship between computer memory and disk storage, for which a number of appropriate and erroneous conceptions emerged. These are given below.

Exhibit 1: Transcripts of appropriate and erroneous conceptions

How is information stored on the disk?

Expert 1: Basically it is on the disk, that's magnetic ... Its information stored, like north/south ... depending on whether south's representing a bit pattern or whether it is on or off basically ... It reads it as a binary code, and spins in bits and bites and all that to work out what the information is saying ... The computer only thinks in 'on' and 'off', which is binary.

Expert 2: Well, there is a read head on the disk, in the disk drive and it polarises the disk in order to represent 0 and 1's. It is not 0 and 1's on the disk its magnetic fields and stuff like that.

Novice 1: I don't know the technical side ... Is it anything similar how they put music on a record, or something like that? ... It has grooves in it like a disk ... very fine because you can store a lot of memory on it. ... Like a record. I suppose it is floppy. It is very flexible.

Novice 2: I would imagine like a record player, with a record how its got all grooves ... And it just sort of puts it [the needle] into grooves and then sort of takes it off later.

Novice 3: I always imagine it to be something like a plastic record or something inside that disk that has grooves in it that contained all the information. The information gets stored inside the grooves sort of thing.

The software uses the students name to personalise responses. The students were then ask d, with nothing else being changed in any way ...

If we take out the disk, would the computer still remember your name?

Expert 1: It would still be in the program. Yes as long as you don't turn off the CPU, the main memory in there.

Expert 2: Yes, because it is still held in the memory. If that's the same program running and the variables are still there, then it should still remember my name, provided that this power switch is not connected to the computer line. It is stored in RAM.

Novice 1: If I haven't saved it. It won't work. If I haven't saved it, it shouldn't remember my name.

Novice 2: No ... This piece is the same as a human's brain. To remember something or output something, or apply the last information ... so if I took some information from the keyboard and I didn't put it on the floppy disk, then the computer will not remember the information.

Novice 3: No ... Unless you saved ... I suppose you have to save it first and then you take the disk out and then store; I mean that won't come up. I would have to put my disk back into it for it to come back up.

Novice 4: I think it would forget ... Because it would all sort of collapse because that is where its running from, the disk. Its not a hard disk, it is actually running from the disk and if you took it out. Well if you took it out you haven't really saved anything we have just put in, so if you took it out it would only have the original of what it had already on it and it doesn't have my name on it so I think it'll fold. I don't think it would be there when you put it back in.

The question generated as a result of such responses tested student generated conceptions, with responses for the whole group given below. The forth response is considered correct, and the others were mis-conceptions which the students have constructed, and which were outlined by them.

Table 9: Sample Model Question Responses

You have just completed a Logo for your sporting club on your graphics package. You are about to save your work to disk. Which of the following best describes the current situation?	All Students		Computer Science		Education	
	N	%	N	%	N	%
* The Logo and graphics package are both to be found on the disk.	26	16.4	11	15.1	15	17.4
* The Logo is in the computer while the graphics program is on disk	31	19.5	8	11.0	23	26.7
* The Logo and program are in the computer and also on the disk	30	18.9	12	16.4	18	20.9
* The Logo is in the computer, while the program is in the computer and on the disk.	72	45.3	42	57.5	30	34.9

These results tend to confirm the existence of both appropriate conceptions and mis-conceptions, and reveal that more than half of the students held these mis-conceptions. Further, following an analysis of the responses using basic tenets of the methodology outlined to develop an analysis of cognitive principles (Heath, 1964), and extended by Hill, Baker, Talley and Hobday (1980), tentative correlations were established between the model question and the other cognitive and affective measures outlined. These responses correlate significantly with Knowledge (0.328, p=0.01), State Anxiety (-.216, p=0.01), Computer Liking (.270, p=0.01), and Computer Confidence (.218, p=0.01). Further detailed analysis of the interview data will be made to explore these relationships further.

Relationships between cognitive and affective variables

A correlation matrix for the affective and cognitive measures is presented in Table 10. It will be observed that the cognitive and affective measures are closely correlated. The affective measures of computer anxiety, liking of computer interactions, and confidence in using computers are closely related to one another. The table indicates that at the beginning of the computer course computer anxiety correlates -0.68 with liking of computers, and -0.73 with computer confidence, while liking of computers correlates 0.81 with computer confidence.

These affective variables also correlate significantly with computer knowledge. At the beginning of the course computer knowledge correlates -0.37 with computer anxiety, 0.47 with computer liking, and 0.55 with computer confidence. At the end of the course, computer knowledge correlates 0.40 with computer anxiety, 0.50 with computer liking and 0.48 with computer confidence.

Table 10: Correlation coefficient matrix

	Know 1.	Computer Liking 1.	Computer Confid. 1.	Anxiety 2.	Know. 2.	Computer Liking 2.	Computer Confid 2.
Anxiety 1.	-.37**	-.68**	-.73**	.68**	-.35**	-.62**	-.62**
Knowledge 1.		.47**	.55**	-.42**	.79**	.50**	.53**
Computer Liking 1.			.81**	-.57**	.40**	.76**	.69**
Comp. Confidence 1.				-.60**	.44**	.72**	.78**
Anxiety 2.					-.40**	-.69**	-.71**
Knowledge 2.						.50**	.48**
Computer Liking 2.							.83**

** Significant LE .01

NOTE: Variables reflecting measurements taken prior to the commencement of the semester are indicated using a 1, while those taken after the semester are indicated by 2.

Discussion

The results provide some useful information about affective responses and cognitive constructions associated with computer environments. Computer anxiety, confidence and liking are closely interrelated. Furthermore these affective responses are related to gender and to the type of professional program being undertaken at university. In contrast trait anxiety has not differed on the basis of gender or program. It appears, therefore, that the computer anxiety, confidence and liking differences observed between the genders and students in the two types of professional program are related to prior experience with computers and similar types of technology.

Generally, females reveal more anxiety and less confidence than males. Student teachers reveal more anxiety, less confidence and less liking of computer interactions than students enrolled in computer science courses. This last finding might be explained in terms of the likelihood that computer science students would regard the computer as a more important occupational tool than prospective teachers and would have had more previous experience with computers. Certainly the results reveal that the computer science students perceived themselves as having more computer ability than the education students.

The significant interaction between gender and course of study in relation to anxiety, however, also shows that the gender difference depends on the type of professional course chosen. There were no anxiety differences between male and female students in the computer science course, however, female education students were much more computer anxious than their male counterparts. It appears, therefore, that gender differences in computer anxiety will be related to such factors as occupational choice, rather than just to gender, as examined in some previous studies.

It is also of interest that there were no differences relating to gender or course chosen as to perceived self-concept of mathematics ability, though this factor is sometimes nominated as explaining gender differences in regard to computer attitudes and skills. There was, however, a highly significant difference between the computer science students and the education students with respect to self-concept of ability to use computers. The earlier referred to finding of higher anxiety in education students, therefore, is better related to differences in self-concept of ability to use computers than to self-concept of ability in mathematics, language or problem solving.

The results with respect to affective responses parallel those of declarative knowledge. Males and computer science students generally had superior knowledge about computing than did females or education students as a group. Furthermore declarative knowledge about computers is significantly related to the affective responses already discussed. Computer knowledge is negatively related to anxiety, and positively related to confidence and liking of using computers. Of course, the study does not enable conclusions to be drawn about causality. Rather it seems reasonable to conclude that knowledge and affect influence each other. Negative affect will interfere with learning new knowledge about computing, and lack of knowledge about computing will contribute to negative affect about computers. Changing either affect or knowledge will necessitate strategies designed to address both factors. More elaborate models need to be developed to explain this relationship between cognitive and affective variables.

Generally, the computer courses taken by both groups of students had only slight effects on affective responses and cognitive construction. Knowledge about general computing concepts was not taught directly in either course, but increased slightly but significantly from the beginning of the respective courses to the end. However, the gender and group differences as to computer knowledge observed before the courses began were still evident at the end of the courses. Computer anxiety and confidence did not change over the period of the course. Interestingly, liking for computers actually fell significantly over that period. These findings are consistent with other findings that computer courses do not necessarily reduce anxiety or increase confidence or liking of computer interactions (King, 1993; Rosen, Sears and Weil, 1987).

The relationships observed in this study will be further clarified when the analysis of data gathered about the models used by students to understand and explain the computing environment is completed. Results, thus far, indicate that many of the education and computer studies students have erroneous conceptualisations about important aspects of the computer environment. Such misconceptions will interfere with further learning about computer environments and about the effective use of computers in applying them to situations such as teaching or business (Sasse, 1992).

Despite the importance of computer applications in teaching and learning, the results reveal that teacher education students, as a group, are less knowledgable, more anxious, less confident, and have less liking for interactions with computers than other groups of students such as the computer science and business students sampled in the present study. Among teacher education students the results also reveal that female students are more anxious, and less confident with computers than male students. There is much that needs to be done in teacher education, therefore, if male and female student teachers are to graduate with the confidence, understandings and skills needed for them to use computer applications effectively in classroom teaching and learning. Carefully planned courses and application experience addressing both affective responses and cognitive understandings are needed If that important goal is to be achieved.

References

Bandura, A. (1986) *Social foundations of thought and action: A social cognitive theory.* NJ: Prentice Hall.

Benner, P. (1984) *From novice to expert.*: Excellence and power in clinical nursing. California: Addison Wesley.

Bohlin, R.M. (1992) The effects of two instructional conditions on learner's computer anxiety and confidence. in M.R. Simonson, and K. Jurasek *Proceedings of selected research and development presentations at the 1992 National Convention of the Association for Educational Communications and Technology* pp. 40-58 USA: Iowa State Uni.

Boylan, C.R., Hill, D.M., Wallace, A.R., and Wheeler, A.E. (1992) Beyond Stereotypes, *Science Education*. 76 (5), pp. 465-476.

Cambre, M.A., Cook, D.L. (1985) Computer anxiety: Definition, measurement, and correlates *Journal of Educational Computing Research* 1 (1) pp. 37-53.

Gagné, E.D., Yekovich, C.W. and Yekovich, F.R. (1993) *The Cognitive Psychology of School Learning* , New York: Harper.

Glass, C., and Knight, L. (1988) Cognitive fact in computer anxiety. *Cognitive therapy and research*, 12, pp. 351-366.

Harrington, K. (1988) Computer anxiety: A cloud on the horizon of technological intervention. *Organization Development Journal*, 6, pp. 51-55.

Heath, R.W. (1964) Curriculum, cognition, and educational measurement *Educational and psychological measurement*. 24. pp. 239 - 253.

Hill, D.M., Baker, S.R., Talley, L.H., and Hobday, M.D. (1980) Language preferences of freshman chemistry students. *Journal of Research in Science Teaching*. 17 (6). pp. 571 - 576.

Howard, G.S. (1984) *Computer anxiety and the use of microcomputers in management.* Ann Arbor: UMI Research.

Howard, G.S., Murphy, C.M., and Thomas, G.N. (1987) Computer anxiety considerations for design of introductory computer courses. *Educational Research Quarterly*. 11 (4), pp. 13-22.

Hunt, N.P., and Bohlin, R.M. (1991) *Entry attitudes of students towards using computers,* Paper presented at annual meeting of Californian Educational Research Assoc. pp 1-10.

Joncour, N. Sinclair, K.E., and Bailey, M. (1994) *Computer anxiety, computer experience and self efficacy.* Paper presented at the Annual Conference of the Australian Association for Research in Education.

King, J. (1993) Getting anxious about electronic learning. *Australian educational computing.* 8, pp. 351-366.

Loyd B.H., and Gressard, C. (1984) Reliability and factorial variability of computer attitude scales. *Educational and Psychological Measurement*. 44, pp. 501-505.

Martinez, M.E. (1988) *Computer Competence: The first national assessment, Report, Educational Testing Service*, New Jersey: Princeton.

Massoud, S.L. (1991) Computer attitudes and computer knowledge of adult students. *Journal of Educational Computing Research* 7 (3) pp. 269 - 291.

McInerney, V., McInerney, D.M., and Sinclair, K.E. (1994) Student teachers, computer anxiety and computer experience *Journal of Educational Computing Research*, 11(1), pp.27-50.

Okebukola, P. (1993) The gender factor in computer anxiety and interest among some Australian high school students. *Educational Research*, 35, pp. 181-189.

Osborne, R.J. and Freyberg, P. (1985) *Learning in Science Education: The implications of children's science* Sydney: Heinemann.

Osborne, R.J. and Gilbert, J.K. (1979) Investigating student understanding of basic physics concepts using an interview-about-instances technique. *Research in Science Education* 9, pp. 85-93.

Payne, S.J., (1992) On models and cognitive artifacts. in Y. Rogers, A. Rutherford and P.A. Bibby (eds) *Models of the Mind: Theory, perspective and application*. London: Academic Press.

Pope-Davis, D., and Vispoel, W. (1993) How instruction influences attitudes of college men and women towards computers. *Computers in Human Behaviour*, 9, pp. 83-93.

Rosen, L.D., Sears, D.C. and Weil, M.W. (1987) Session VII Computerphobia *Behavior Research Methods, Instruments and Computers* 19 (2) pp. 167-179.

Sasse, M.A. (1992) User models of computer systems. in Y. Rogers, A. Rutherford and P.A. Bibby (eds) *Models of the Mind: Theory, perspective and application*. London: Academic Press.

Simonson, M.R., Maurer, M., Montag-Torardi, M., Whitaker, M. (1987) Development of a Standardised test of computer literacy and a computer anxiety index, *Journal of Educational Computing Research* 3 (2) pp. 231-247.

Spielberger, C.D., Gorsuch, R.L., and Lushene, R.E. (1970) *STAI Manual*. California: Consulting Psychologists Press.

Wallace, A., Hemmings, B., Hill, D. (1991) Student perceptions about computers and the computing environment. *Computer Education* 69, pp. 20 - 23.

Wallace, A.R., Hemmings, B., and Hill, D. (1994) CPD: Computer-Promoted Dialogue as a research tool. *Unicorn* 20 (1), pp. 73-77.